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Specification and Drawings, as originally filed, with Application for Patent Serial No:
2,426,512, on April 22, 2003, by **IDELIX SOFTWARE INC.**, assignee of Garth
Shoemaker, for "Positioning and Manipulating Detail-in-Context Lenses in 2D and 3D
Data Through the Application of Eye Tracking or Position Tracking".


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POSITIONING AND MANIPULATING DETAIL-IN-CONTEXT LENSES IN 2D AND 3D DATA THROUGH THE APPLICATION OF EYE TRACKING OR POSITION TRACKING

BACKGROUND OF THE INVENTION

5 Display screens are the primary visual display interface to a computer. One problem with these visual display screens is that they are limited in size, thus presenting a challenge to user interface design, particularly when larger amounts of information is to be displayed. This problem is normally referred to as the "screen real estate problem".

10 Well-known solutions to this problem include panning, zooming, scrolling or combinations thereof. While these solutions are suitable for a large number of visual display applications, these solutions become less effective where the visual information is spatially related, such as maps, newspapers and such like. In this type of information display, panning, zooming and/or scrolling is not as effective as much of the context of the panned, zoomed or scrolled display is hidden.

15 A recent solution to this problem is the application of "detail-in-context" presentation techniques. Detail-in-context is the magnification of a particular region of interest (the "focal region") in a data presentation while preserving visibility of the surrounding information. This technique has applicability to the display of large surface area media, such as maps, on limited size computer screens such as personal digital assistance (PDA's) and cell phones.

20 In the detail-in-context discourse, differentiation is often made between the terms "representation" and "presentation". A representation is a formal system, or mapping, for specifying raw information or data that is stored in a computer or data processing system. For example, a digital map of a city is a representation of raw data including street names and the relative geographic location of streets and utilities. Such a representation may be displayed
25 visually on computer screen or printed on paper. On the other hand, a presentation is a spatial organization of a given representation that is appropriate for the task at hand. Thus, a presentation of a representation organizes such things as the point of view and the relative emphasis of different parts or regions of the representation. For example, a digital map of a city may be presented with a region magnified to reveal street names.

- 2 -

In general, a detail-in-context presentation may be considered as a distorted view (or distortion) of a portion of the original representation where the distortion is the result of the application of a "lens" like distortion function to the original representation. A detailed review of various detail-in-context presentation techniques such as Elastic Presentation Space ("EPS") may be found in a publication by Marianne S. T. Carpendale, entitled "A Framework for Elastic Presentation Space" (Burnaby, British Columbia: Simon Fraser University, 1999), and incorporated herein by reference.

Development of increasingly powerful computing devices has lead to new possibilities for applications of detail-in-context viewing. At the same time, the demand for user control over the parameters of a detail-in-context lens has increased.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may best be understood by referring to the following description and accompanying drawings which illustrate the invention. In the drawings:

FIG. 1 is a graphical construction illustrating a 3D perspective viewing frustum in accordance with known elastic presentation space graphics technology;

FIG. 2 is a cross-sectional view illustrating a presentation in accordance with known elastic presentation space graphics technology;

FIG. 3 is a block diagram illustrating an exemplary data processing system for implementing an embodiment of the invention; and,

FIG. 4 a partial screen capture illustrating a GUI having lens control elements for user interaction with detail-in-context data presentations in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following description, numerous specific details are set forth to provide a thorough understanding of the invention. However, it is understood that the invention may be practiced without these specific details. In other instances, well-known software, circuits, structures and techniques have not been described or shown in detail in order not to obscure the invention. The term "data processing system" is used herein to refer to any machine for processing data,

including the computer systems and network arrangements described herein. The term "Elastic Presentation Space" or "EPS" is used herein to refer to techniques that allow for the adjustment of a visual presentation without interfering with the information content of the representation. The adjective "elastic" is included in the term as it implies the capability of stretching and deformation and subsequent return to an original shape. EPS graphics technology is described by Carpendale in *A Framework for Elastic Presentation Space* (Carpendale, Marianne S. T., *A Framework for Elastic Presentation Space* (Burnaby, British Columbia: Simon Fraser University, 1999)) which is incorporated herein by reference. In EPS graphics technology, a two-dimensional visual representation is placed onto a surface; this surface is placed in three-dimensional space; the surface, containing the representation, is viewed through perspective projection; and the surface is manipulated to effect the reorganization of image details. The presentation transformation is separated into two steps: surface manipulation or distortion and perspective projection. In the drawings, like numerals refer to like structures or processes.

Referring to FIG. 1, there is shown a graphical representation 100 of the geometry for constructing a three-dimensional (3D) perspective viewing frustum 220 relative to an x, y, z coordinate system in accordance with known elastic presentation space ("EPS") graphics technology. In the EPS, detail-in-context views of 2D visual representations are created with sight-line aligned distortions of a two-dimensional (2D) information presentation surface within a 3D perspective viewing frustum 220. In EPS, magnification of regions of interest and the accompanying compression of the contextual region to accommodate this change in scale are produced by the movement of regions of the surface towards the viewpoint 240 located at the apex of the pyramidal shape 220 containing the frustum. The process of projecting these transformed layouts via a perspective projection results in a new 2D layout which includes the zoomed and compressed regions. The use of the third dimension and perspective distortion to provide magnification in EPS provides a meaningful metaphor for the process of distorting the information presentation surface. The 3D manipulation of the information presentation surface in such a system is an intermediate step in the process of creating a new 2D layout of the information.

Referring to FIG. 2, there is shown geometrical representation of a presentation 200 in accordance with known EPS graphics technology. EPS graphics technology employs viewer-aligned perspective projections to produce detail-in-context presentations in a reference view

plane 201 which may be viewed on a display. Undistorted 2D data points are located in a basal plane 210 of a 3D perspective viewing volume or frustum 220 which is defined by extreme rays 221 and 222 and the basal plane 210. A viewpoint ("VP") 240 is located above the centre point of the basal plane 210 and reference view plane 201. Points in the basal plane 210 are displaced
5 upward onto a distorted surface 230 which is defined by a general 3D distortion function (i.e. a detail-in-context distortion basis function). The direction of the viewer-aligned perspective projection corresponding to the distorted surface 230 is indicated by the line FPo - FP 231 drawn from a point FPo 232 in the basal plane 210 through the point FP 233 which corresponds to the focus or focal region or focal point of the distorted surface 230.

10 To reiterate, EPS refers to a collection of know-how and techniques for performing "detail-in-context viewing" (also known as "multi-scale viewing" and "distortion viewing") of information such as images, maps, and text, using a projection technique summarized below. EPS is applicable to multidimensional data and is well suited to implementation on a computer for dynamic detail-in-context display on an electronic display surface such as a monitor. In the case
15 of two dimensional data, EPS is typically characterized by magnification of areas of an image where detail is desired, in combination with compression of a restricted range of areas of the remaining information (the "context"), the end result typically giving the appearance of a lens having been applied to the display surface. EPS has numerous advantages over conventional zoom, pan, and scroll technologies, including the capability of preserving the visibility of
20 information outside the local region of interest.

In general, in EPS, the source image to be viewed is located in the basal plane. Magnification and compression are achieved through elevating elements of the source image relative to the basal plane, and then projecting the resultant distorted surface onto the reference view plane. EPS performs detail-in-context presentation of n-dimensional data through the use of a procedure
25 wherein the data is mapped into a region in an (n+1) dimensional space, manipulated through perspective projections in the (n+1) dimensional space, and then finally transformed back into n-dimensional space for presentation.

For example, and referring to FIGS. 1 and 2, in two dimensions, EPS can be implemented through the projection of an image onto a reference plane 201 in the following manner. The
30 source image is located on a basal plane 210, and those regions of interest 233 of the image for

which magnification is desired are elevated so as to move them closer to a reference plane situated between the reference viewpoint 240 and the reference view plane (RVP) 201. Magnification of the "focal region" 233 closest to the RVP varies inversely with distance from the RVP 201. As shown in FIGS. 1 and 2, compression of regions outside the focal region 233 is a function of both distance from the RVP 201, and the gradient of the function describing the vertical distance from the RVP 201 with respect to horizontal distance from the focal region 233. The resultant combination of magnification and compression of the image as seen from the reference viewpoint 240 results in a lens-like effect similar to that of a magnifying glass applied to the image, and the resultant distorted image may be referred to as a "pliable display surface". Hence, the various functions used to vary the magnification and compression of the image via vertical displacement from the basal plane 210 are described as lenses, lens types, or lens functions. Lens functions that describe basic lens types with point and circular focal regions, as well as certain more complex lenses and advanced capabilities such as folding, have previously been described by Carpendale.

System. Referring to FIG. 3, there is shown a block diagram of an exemplary data processing system 300 for implementing an embodiment of the invention. The data processing system is suitable for implementing EPS technology in conjunction with eye tracking, position tracking, and a graphical user interface ("GUI"). The data processing system 300 includes an input device 310, a central processing unit or CPU 320, memory 330, a display 340, and eye tracking and/or position tracking hardware 351, 352. The input device 310 may include a keyboard, mouse, trackball, or similar device. The CPU 320 may include dedicated coprocessors and memory devices. The memory 330 may include RAM, ROM, databases, or disk devices. The display 340 may include a computer screen or terminal device. And, the eye tracking and/or position tracking hardware 351, 352 may include cameras, touch-screens, wands, and electromagnetic sensors with appropriate controllers. The data processing system 300 has stored therein data representing sequences of instructions which when executed cause the method described herein to be performed. Of course, the data processing system 300 may contain additional software and hardware a description of which is not necessary for understanding the invention.

GUI with Lens Control Elements. As mentioned, detail-in-context presentations of data using techniques such as pliable surfaces, as described by Carpendale, are useful in presenting large amounts of information on limited-size display surfaces. Detail-in-context views allow

magnification of a particular region of interest (the "focal region") 233 in a data presentation while preserving visibility of the surrounding information 210. In the following, a GUI having lens control elements that can be implemented in software and applied to the control of detail-in-context data presentations, including EPS and pliable surfaces, is described. The software can be loaded into and run by the exemplary data processing system 300 of FIG. 3.

Referring to FIG. 4, there is a partial screen capture illustrating a GUI 400 having lens control elements for user interaction with detail-in-context data presentations in accordance with an embodiment of the invention. Detail-in-context data presentations are characterized by magnification of areas of an image where detail is desired, in combination with compression of a restricted range of areas of the remaining information (i.e. the "context"), the end result typically giving the appearance of a "lens" having been applied to the display screen surface. This "lens" 410 includes a "focal region" 420 having high magnification, a surrounding "shoulder region" 430 where information is typically visibly compressed, and a "base" 412 surrounding the shoulder region 430 and defining the extent of the lens 410. In FIG. 4, the lens 410 is shown with a circular shaped base 412 (or outline) and with a focal region 420 lying near the center of the lens 410. However, the lens 410 and focal region 420 may have any desired shape. Referring again to FIG. 2, the lens 410 corresponds to the projection of the distorted surface 230 and focal region 233 onto the reference plane 201.

In general, the GUI 400 has lens control elements that, in combination, provide for the interactive control of the lens 410. The effective control of the characteristics of the lens 410 by a user (i.e. dynamic interaction with a detail-in-context lens) is advantageous. At any given time, one or more of these lens control elements may be made visible to the user on the display surface 340 by appearing as overlay icons on the lens 410. Interaction with each element is performed via the motion of a pointing device 310 (e.g. mouse), with the motion resulting in an appropriate change in the corresponding lens characteristic. As will be described, selection of which lens control element is actively controlled by the motion of the pointing device 310 at any given time is determined by the proximity of the icon representing the pointing device 310 on the display surface 340 (e.g. cursor) to the appropriate component of the lens 410. For example, "dragging" of the pointing device at the periphery of the bounding rectangle of the lens base 412 causes a corresponding change in the size of the lens 410 (i.e. "resizing"). Thus, the GUI 400 provides the

- 7 -

user with a visual representation of which lens control element is being adjusted through the display of one or more corresponding icons.

For ease of understanding, the following discussion will be in the context of using a two-dimensional pointing device 310 that is a mouse, but it will be understood that the invention may be practiced with other 2-D or 3-D (or even greater numbers of dimensions) pointing devices including a trackball and keyboard.

A mouse 310 controls the position of a cursor icon 401 that is displayed on the display screen 340. The cursor 401 is moved by moving the mouse 310 over a flat surface, such as the top of a desk, in the desired direction of movement of the cursor 401. Thus, the two-dimensional movement of the mouse 310 on the flat surface translates into a corresponding two-dimensional movement of the cursor 401 on the display screen 340.

A mouse 310 typically has one or more finger actuated control buttons (i.e. mouse buttons). While the mouse buttons can be used for different functions such as selecting a menu option pointed at by the cursor 401, the disclosed invention may use a single mouse button to "select" a lens 410 and to trace the movement of the cursor 401 along a desired path. Specifically, to select a lens 410, the cursor 401 is first located within the extent of the lens 410. In other words, the cursor 401 is "pointed" at the lens 410. Next, the mouse button is depressed and released. That is, the mouse button is "clicked". Selection is thus a point and click operation. To trace the movement of the cursor 401, the cursor 401 is located at the desired starting location, the mouse button is depressed to signal the computer 320 to activate a lens control element, and the mouse 310 is moved while maintaining the button depressed. After the desired path has been traced, the mouse button is released. This procedure is often referred to as "clicking" and "dragging" (i.e. a click and drag operation). It will be understood that a predetermined key on a keyboard 310 could also be used to activate a mouse click or drag. In the following, the term "clicking" will refer to the depression of a mouse button indicating a selection by the user and the term "dragging" will refer to the subsequent motion of the mouse 310 and cursor 401 without the release of the mouse button.

The GUI 400 may include the following lens control elements: move, pickup, resize base, resize focus, fold, and magnify. Each of these lens control elements has at least one lens control icon or alternate cursor icon associated with it. In general, when a lens 410 is selected by a user through

a point and click operation, the following lens control icons may be displayed over the lens 410: pickup icon 450, base outline icon 412, base bounding rectangle icon 411, focal region bounding rectangle icon 421, handle icons 481, 482, 491, and magnify slide bar icon 440. Typically, these icons are displayed simultaneously after selection of the lens 410. In addition, when the cursor 401 is located within the extent of a selected lens 410, an alternate cursor icon 460, 470, 480, 490 may be displayed over the lens 410 to replace the cursor 401 or may be displayed in combination with the cursor 401. These lens control elements, corresponding icons, and their effects on the characteristics of a lens 410 are described below with reference to FIG. 4.

In general, when a lens 410 is selected by a point and click operation, bounding rectangle icons 411, 421 are displayed surrounding the base 412 and focal region 420 of the selected lens 410 to indicate that the lens 410 has been selected. With respect to the bounding rectangles 411, 421 one might view them as glass windows enclosing the lens base 412 and focal region 420, respectively. The bounding rectangles 411, 421 include handle icons 481, 482, 491 allowing for direct manipulation of the enclosed base 412 and focal region 420 as will be explained below. Thus, the bounding rectangles 411, 421 not only inform the user that the lens 410 has been selected, but also provide the user with indications as to what manipulation operations might be possible for the selected lens 410 through use of the displayed handles 481, 482, 491. Note that it is well within the scope of the present invention to provide a bounding region having a shape other than generally rectangular. Such a bounding region could be of any of a great number of shapes including oblong, oval, ovoid, conical, cubic, cylindrical, polyhedral, spherical, etc.

Moreover, the cursor 401 provides a visual cue indicating the nature of an available lens control element. As such, the cursor 401 will generally change in form by simply pointing to a different lens control icon 450, 412, 411, 421, 481, 482, 491, 440. For example, when resizing the base 412 of a lens 410 using a corner handle 491, the cursor 401 will change form to a resize icon 490 once it is pointed at (i.e. positioned over) the corner handle 491. The cursor 401 will remain in the form of the resize icon 490 until the cursor 401 has been moved away from the corner handle 491.

Move. Lateral movement of a lens 410 is provided by the move lens control element of the GUI. This functionality is accomplished by the user first selecting the lens 410 through a point and click operation. Then, the user points to a point within the lens 410 that is other than a point

lying on a lens control icon 450, 412, 411, 421, 481, 482, 491, 440. When the cursor 401 is so located, a move icon 460 is displayed over the lens 410 to replace the cursor 401 or may be displayed in combination with the cursor 401. The move icon 460 not only informs the user that the lens 410 may be moved, but also provides the user with indications as to what movement operations are possible for the selected lens 410. For example, the move icon 460 may include arrowheads indicating up, down, left, and right motion. Next, the lens 410 is moved by a click and drag operation in which the user clicks and drags the lens 410 to the desired position on the screen 340 and then releases the mouse button 310. The lens 410 is locked in its new position until a further pickup and move operation is performed.

Pickup. Lateral movement of a lens 410 is also provided by the pickup lens control element of the GUI. This functionality is accomplished by the user first selecting the lens 410 through a point and click operation. As mentioned above, when the lens 410 is selected a pickup icon 450 is displayed over the lens 410 near the centre of the lens 410. Typically, the pickup icon 450 will be a crosshairs. In addition, a base outline 412 is displayed over the lens 410 representing the base 412 of the lens 410. The crosshairs 450 and lens outline 412 not only inform the user that the lens has been selected, but also provides the user with an indication as to the pickup operation that is possible for the selected lens 410. Next, the user points at the crosshairs 450 with the cursor 401. Then, the lens outline 412 is moved by a click and drag operation in which the user clicks and drags the crosshairs 450 to the desired position on the screen 340 and then releases the mouse button 310. The full lens 410 is then moved to the new position and is locked there until a further pickup operation is performed. In contrast to the move operation described above, with the pickup operation, it is the outline 412 of the lens 410 that the user repositions rather than the full lens 410.

Resize Base. Resizing of the base 412 (or outline) of a lens 410 is provided by the resize base lens control element of the GUI. After the lens 410 is selected, a bounding rectangle icon 411 is displayed surrounding the base 412. The bounding rectangle 411 includes handles 491. These handles 491 can be used to stretch the base 412 taller or shorter, wider or narrower, or proportionally larger or smaller. The corner handles 491 will keep the proportions the same while changing the size. The middle handles (not shown) will make the base 412 taller or shorter, wider or narrower. Resizing the base 412 by the corner handles 491 will keep the base 412 in proportion. Resizing the base 412 by the middle handles (not shown) will change the proportions

of the base 412. That is, the middle handles (not shown) change the aspect ratio of the base 412 (i.e. the ratio between the height and the width of the bounding rectangle 411 of the base 412).

When a user points at a handle 491 with the cursor 401 a resize icon 490 may be displayed over the handle 491 to replace the cursor 401 or may be displayed in combination with the cursor 401.

5 The resize icon 490 not only informs the user that the handle 491 may be selected, but also provides the user with indications as to the resizing operations that are possible with the selected handle. For example, the resize icon 490 for a corner handle 491 may include arrows indicating proportional resizing. The resize icon (not shown) for a middle handle (not shown) may include arrows indicating width resizing or height resizing. After pointing at the desired handle 491, the
10 user would click and drag the handle 491 until the desired shape and size for the base 412 is reached. Once the desired shape and size are reached, the user would release the mouse button 310. The base 412 of the lens 410 is then locked in its new size and shape until a further base resize operation is performed.

Resize Focus. Resizing of the focal region 420 of a lens 410 is provided by the resize focus lens
15 control element of the GUI. After the lens 410 is selected, a bounding rectangle icon 421 is displayed surrounding the focal region 420. The bounding rectangle 421 includes handles 481, 482. These handles 481, 482 can be used to stretch the focal region 420 taller or shorter, wider or narrower, or proportionally larger or smaller. The corner handles 481 will keep the proportions the same while changing the size. The middle handles 482 will make the focal region
20 420 taller or shorter, wider or narrower. Resizing the focal region 420 by the corner handles 481 will keep the focal region 420 in proportion. Resizing the focal region 420 by the middle handles 482 will change the proportions of the focal region 420. That is, the middle handles 482 change the aspect ratio of the focal region 420 (i.e. the ratio between the height and the width of the bounding rectangle 421 of the focal region 420). When a user points at a handle 481, 482 with
25 the cursor 401 a resize icon 480 may be displayed over the handle 481, 482 to replace the cursor 401 or may be displayed in combination with the cursor 401. The resize icon 480 not only informs the user that a handle 481, 482 may be selected, but also provides the user with indications as to the resizing operations that are possible with the selected handle. For example, the resize icon 480 for a corner handle 481 may include arrows indicating proportional resizing.
30 The resize icon 480 for a middle handle 482 may include arrows indicating width resizing or height resizing. After pointing at the desired handle 481, 482, the user would click and drag the

handle 481, 482 until the desired shape and size for the focal region 420 is reached. Once the desired shape and size are reached, the user would release the mouse button 310. The focal region 420 is then locked in its new size and shape until a further focus resize operation is performed.

- 5 *Fold.* Folding of the focal region 420 of a lens 410 is provided by the fold control element of the GUI. In general, control of the degree and direction of folding (i.e. skewing of the viewer aligned vector 231 as described by Carpendale) is accomplished by a click and drag operation on a point 471, other than a handle 481, 482, on the bounding rectangle 421 surrounding the focal region 420. The direction of folding is determined by the direction in which the point 471 is dragged.
- 10 The degree of folding is determined by the magnitude of the translation of the cursor 401 during the drag. In general, the direction and degree of folding corresponds to the relative displacement of the focus 420 with respect to the lens base 410. In other words, and referring to FIG. 2, the direction and degree of folding corresponds to the displacement of the point FP 233 relative to the point FPo 232, where the vector joining the points FPo 232 and FP 233 defines the viewer aligned vector 231.
- 15

- In particular, after the lens 410 is selected, a bounding rectangle icon 421 is displayed surrounding the focal region 420. The bounding rectangle 421 includes handles 481, 482. When a user points at a point 471, other than a handle 481, 482, on the bounding rectangle 421 surrounding the focal region 420 with the cursor 401, a fold icon 470 may be displayed over the
- 20 point 471 to replace the cursor 401 or may be displayed in combination with the cursor 401. The fold icon 470 not only informs the user that a point 471 on the bounding rectangle 421 may be selected, but also provides the user with indications as to what fold operations are possible. For example, the fold icon 470 may include arrowheads indicating up, down, left, and right motion. By choosing a point 471, other than a handle 481, 482, on the bounding rectangle 421 a user may
- 25 control the degree and direction of folding. To control the direction of folding, the user would click on the point 471 and drag in the desired direction of folding. To control the degree of folding, the user would drag to a greater or lesser degree in the desired direction of folding. Once the desired direction and degree of folding is reached, the user would release the mouse button 310. The lens 410 is then locked with the selected fold until a further fold operation is
- 30 performed.

Magnify. Magnification of the lens 410 is provided by the magnify lens control element of the GUI. After the lens 410 is selected, the magnify control is presented to the user as a slide bar icon 440 near or adjacent to the lens 410 and typically to one side of the lens 410. Sliding the bar 441 of the slide bar 440 results in a proportional change in the magnification of the lens 410. The slide bar 440 not only informs the user that magnification of the lens 410 may be selected, but also provides the user with an indication as to what level of magnification is possible. The slide bar 440 includes a bar 441 that may be slid up and down, or left and right, to adjust and indicate the level of magnification. To control the level of magnification, the user would click on the bar 441 of the slide bar 440 and drag in the direction of desired magnification level. Once the desired level of magnification is reached, the user would release the mouse button 310. The lens 410 is then locked with the selected magnification until a further magnification operation is performed.

Typically, the focal region 420 is an area of the lens 410 having constant magnification (i.e. if the focal region is a plane). Again referring to FIGS. 1 and 2, magnification of the focal region 420, 233 varies inversely with the distance from the focal region 420, 233 to the reference view plane (RVP) 201. Magnification of areas lying in the shoulder region 430 of the lens 410 also varies inversely with their distance from the RVP 201. Thus, magnification of areas lying in the shoulder region 430 will range from unity at the base 412 to the level of magnification of the focal region 420.

Icon Hiding. Advantageously, a user may choose to hide one or more lens control icons 450, 412, 411, 421, 481, 482, 491, 440 shown in FIG. 4 from view so as not to impede the user's view of the data (i.e. visual information) within the lens 410. This may be helpful, for example, during a move operation. A user may select this option through means such as a menu or lens property dialog box.

Positioning and Manipulating Detail-In-Context Lenses in 2D And 3D Data Through the Application of Eye Tracking or Position Tracking. As mentioned, detail-in-context viewing is a technique applicable to 2D or 3D data that allows for data to magnified locally while maintaining continuity of data. In two dimensions, an arbitrarily shaped region of interest is magnified in place within the data, while a surrounding band of variable magnification connects the region of interest with the surrounding image. The magnified region is referred to as the "focal region," the surrounding band of variable magnification is referred to as the "shoulder region," and the

surrounding image is referred to as the "base image." The focal region and shoulder region together comprise the lens. When applied to three dimensional data, the lens concept itself can be extended into three dimensions. The lens typically exists as a cylinder (although it can be other shapes) of magnification that extends from the viewpoint through the point of interest in the data.

- 5 The cylinder of magnification can be of finite or infinite depth. The magnification cylinder can act on the data by magnifying objects, displacing objects, or deforming individual objects.

In either two dimensions or three dimensions, it is desirable to have a method of positioning and manipulating the lens. Such parameters as lens position, lens size, and lens magnification may need to be adjusted by the user. The present invention deals with the manipulation of lens parameters through the use of eye tracking technology or the sensing of position of physical objects.

Eye Tracking and Detail-In-Context Lenses. Eye tracking technology typically consists of one or more cameras that survey a scene, identify the eyes of people in the scene, and through some technique determine the direction that the eyes are looking. For desktop applications the camera typically sits on a desk near a monitor and is pointed towards the chair at which a user would sit. When the user sits at the chair and uses the computer, the eye tracker can identify the point on the screen at which the user is looking. According to one aspect of the present invention, desktop eye-tracking is combined with detail-in-context viewing. Note that the techniques described below can be applied to both 2D and 3D lenses.

- 20 1. Positioning of Lenses: The eye tracker is able to determine the point on the screen at which a user is looking. With a detail-in-context lens on the screen, it is possible to position said lens at the location on the screen at which the user is looking.
- 25 2. Manipulation of Lenses: Eye tracking could be used to manipulate parameters other than lens position. For example, the eye gaze point of interest and eye movement could be used to change parameters such as lens size and magnification level.
3. Eye Gestures: Eye gestures could be used to change mode or perform operations. For example, a prolonged blink could be used to activate or deactivate a lens.

4. Movement Damping: As human gaze tends to include a certain amount a noise (unintended minor fluctuations in gaze direction), it may be desirable to apply a damping function to the gaze direction before manipulating lens parameters.
5. Large Screen Applications: Combined use of eye tracking and detail-in-context lenses could be applied to large displays, such as wall-mounted displays or digital whiteboards.
6. Multi-User Scenario: Combined use of eye tracking and detail-in-context lenses could be used by multiple users interacting with one screen. One lens per user could be manipulated.
7. Remote Gaze Awareness: The position and state of a lens as determined by gaze direction could be transmitted over a network to a remote machine in order to impart an awareness to the remote user of the gaze direction of the local user.

The techniques described above for use in desktop and large screen environments can be extended for use in immersive virtual reality environments. Instead of the eye tracker determining the point of interest on the screen through eye tracking, it would determine the direction of gaze through a virtual environment. This could be used to position and manipulate lenses. Furthermore, the use of an eye tracker that can detect focal depth (through the tracking of both eyes of a user) would be able to position a lens at a depth defined by the focal depth.

Position Tracking and Detail-In-Context Lenses. There are a variety of technologies that allow for the tracking of physical objects in three dimensions. These technologies include camera technologies that track objects through optical recognition, and magnetic technologies that track sensors through measurement of magnetic fields. According to one aspect of the invention, detail-in-context lenses are manipulated through the measurement of position, orientation, and movement of physical objects controlled by a user. Examples of embodiments of this invention are as follows:

1. A user is examining a 2D map on a screen. Sensors detect the position and orientation of the user's finger. When the user points at a location on the screen, a lens appears at that point. If the user points at a different location, the lens moves to that location.

2. A user is examining a 3D model on a screen. Sensors detect the position and orientation of a user's finger. When the user points at a location on the screen, a 3D lens is inserted in the data, originating from tip of the finger, and progressing through the data in a direction determined by the finger's orientation.
3. A user is in an immersive virtual reality environment, observing a 3D model floating within reach. The user reaches out and touches a finger within the model at a region of interest. A 3D lens is inserted in the model at the point touched by the user, oriented towards the user's point of view.

Alternative versions of the three previous examples can be constructed to include the sensing of objects other than a user's finger. Examples of other objects that could be used to direct a lens include wands, remote controls, and laser pens.

Data Carrier Product. The sequences of instructions which when executed cause the method described herein to be performed by the exemplary data processing system of FIG. 3 can be contained in a data carrier product according to one embodiment of the invention. This data carrier product can be loaded into and run by the exemplary data processing system of FIG. 3.

Computer Software Product. The sequences of instructions which when executed cause the method described herein to be performed by the exemplary data processing system of FIG. 3 can be contained in a computer software product according to one embodiment of the invention. This computer software product can be loaded into and run by the exemplary data processing system of FIG. 3.

Integrated Circuit Product. The sequences of instructions which when executed cause the method described herein to be performed by the exemplary data processing system of FIG. 3 can be contained in an integrated circuit product including a coprocessor or memory according to one embodiment of the invention. This integrated circuit product can be installed in the exemplary data processing system of FIG. 3.

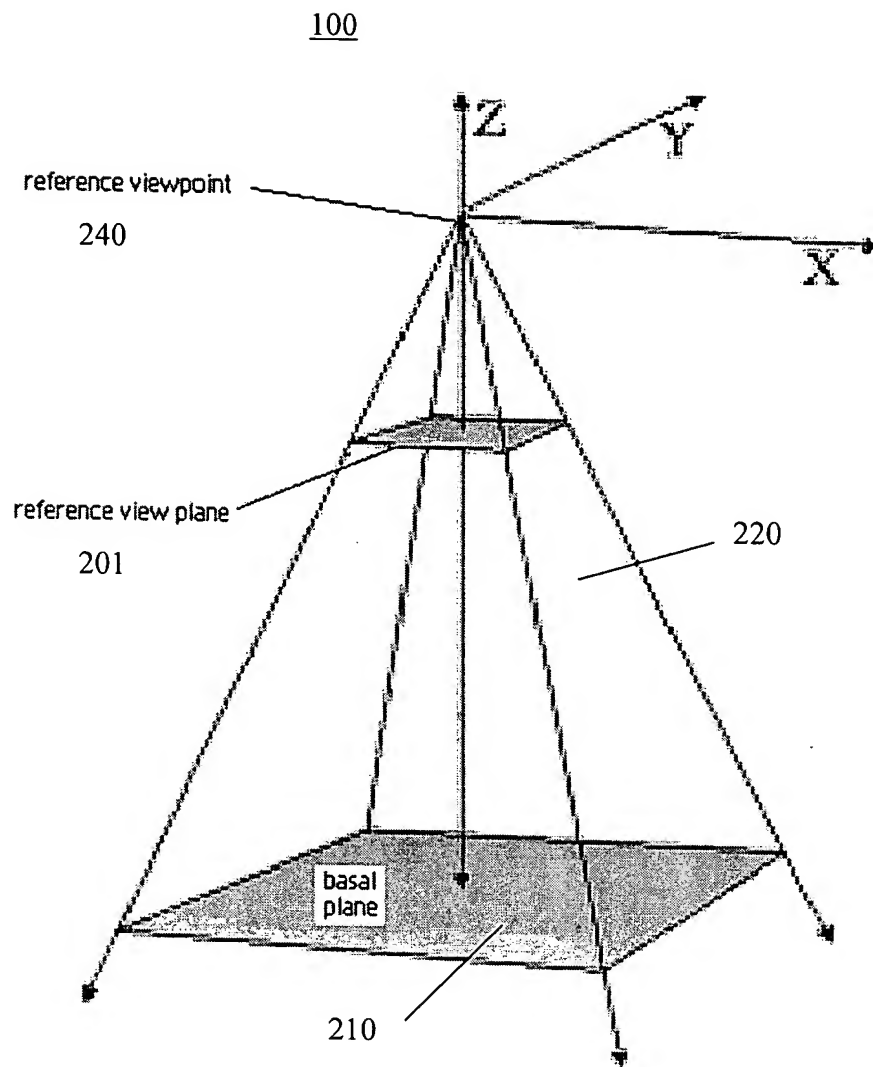


FIG. 1

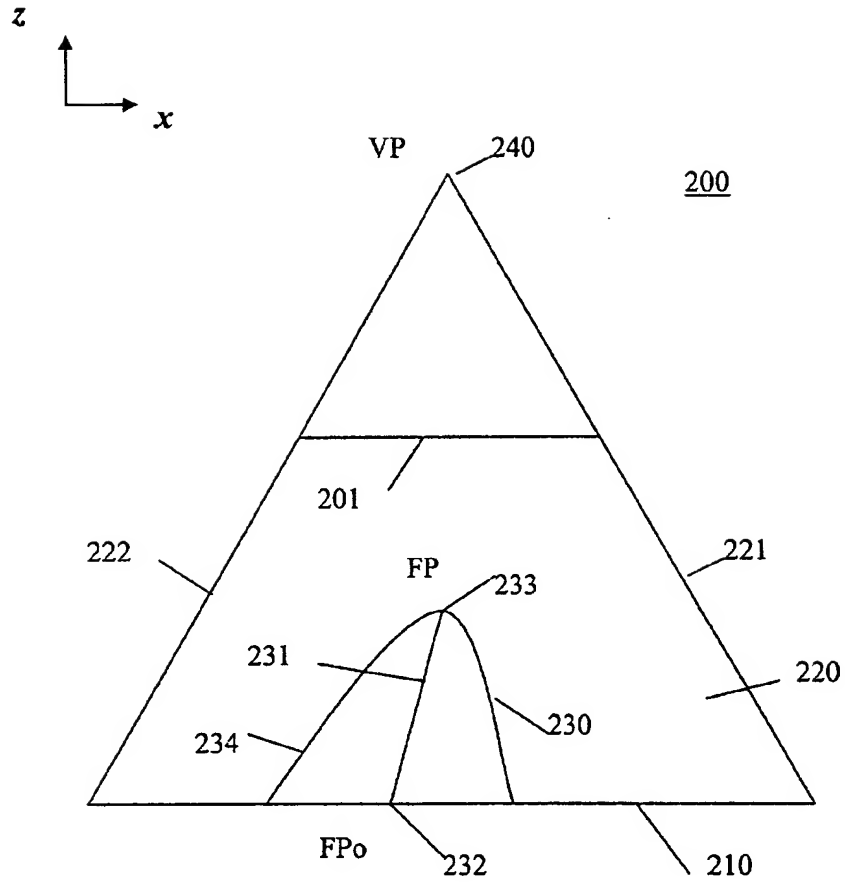


FIG. 2

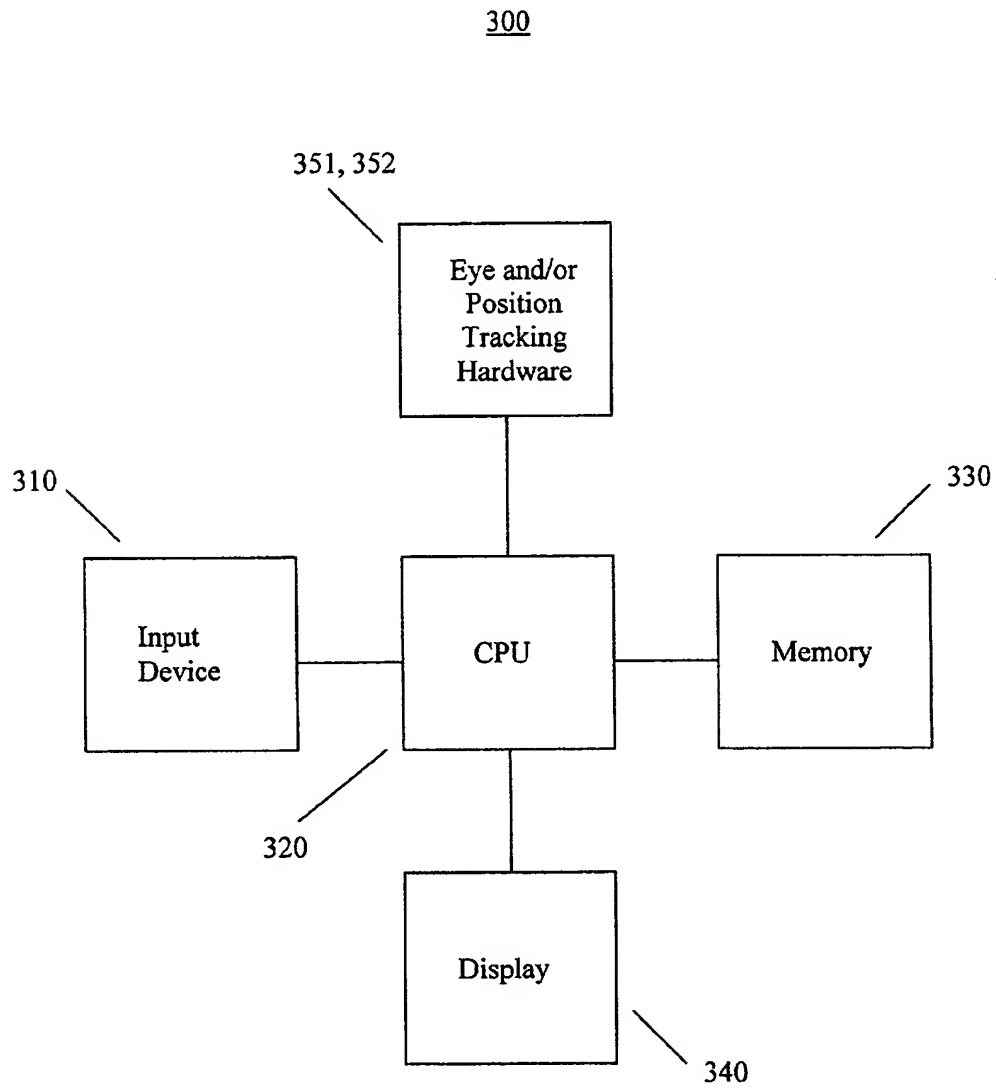


FIG. 3

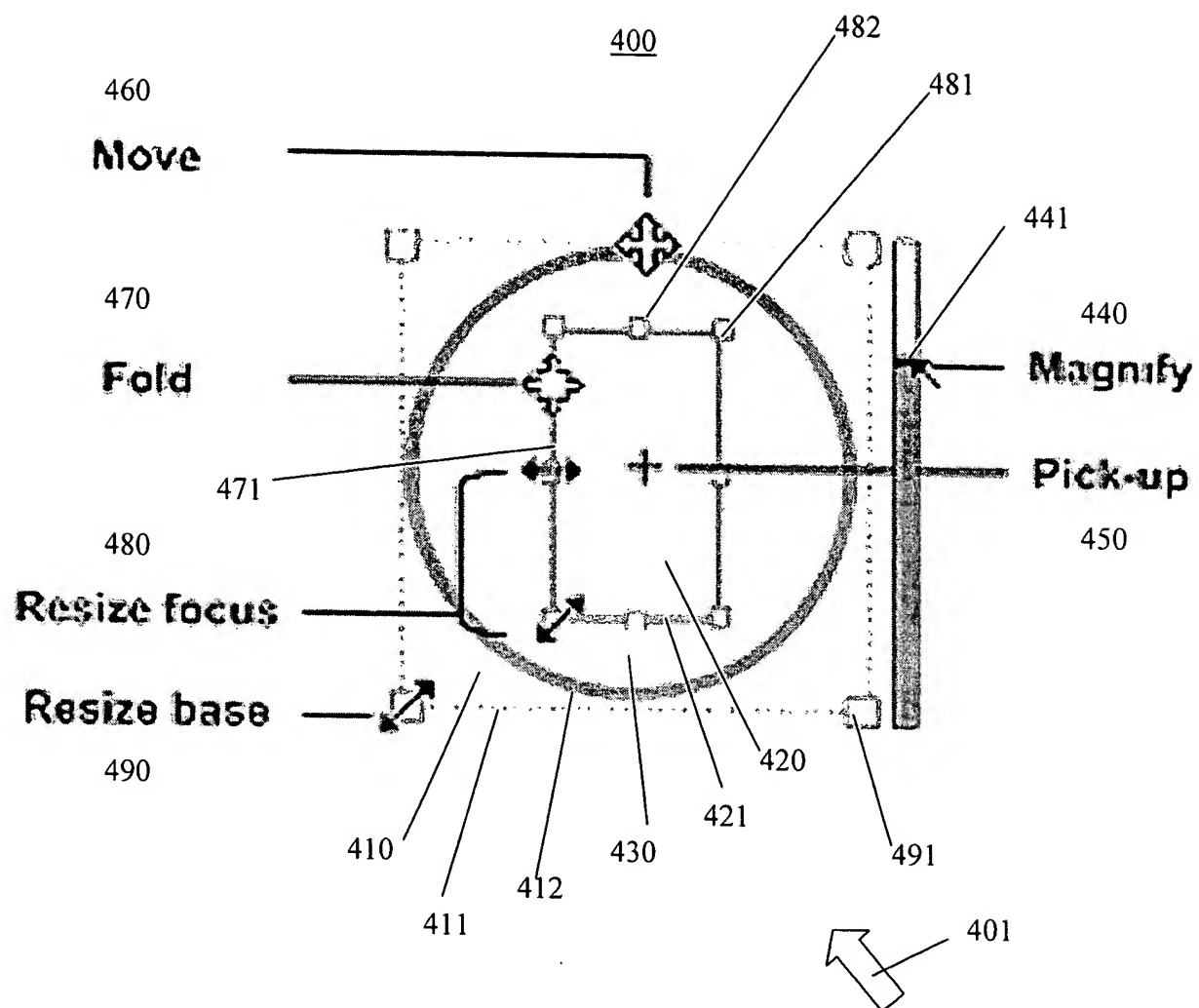


FIG. 4